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PATENT APPLN. NO. 10/600,571
SUBMISSION UNDER 37 C.F.R. § 1.114

PATENT

REMARKS

Claim 1 has been amended to include the limitations of claim 6. Claims 5 and 6 have been canceled.

In the final Office Action dated August 15, 2006, claims 1 to 8 and 11 to 15 were rejected under 35 U.S.C. 103(a) as being unpatentable over Katoh et al. (U.S. Patent No. 5,402,641; hereinafter "Katoh") in view of Leyer et al. (U.S. Patent No. 5,643,542; hereinafter "Leyer"). A response to the action was filed November 15, 2006.

In an Advisory Action dated December 5, 2006, the Office maintained the rejection of the claims.

In reply to the reasons for maintaining the rejection, applicants note the following.

Regarding Katoh:

Katoh describes lean combustion (see claim 1). However, in Katoh, a three-way catalyst is used as an exhaust gas purification catalyst (see claim 2, Description of Related Art).

Regarding the exhaust gas purification using the three-way catalyst, it is well known in the art that the lean and rich of the A/F value is about 14.7 ± 0.3 (please refer to the excerpt from

Taylor, K. "Automobile Catalytic Converters" in *Catalysis Science and Technology* (1984 ed.), vol. 5, pp. 122-123, attached hereto).

Moreover, the exhaust gas described in Katoh corresponds to the first exhaust gas recited in current claim 1 of the present application. However, Katoh does not disclose or suggest the second exhaust gas recited in current claim 1 of the present application.

Katoh is characterized in that:

(1) The NOx absorbent, which absorbs NOx when oxygen in the exhaust gas increases and releases the absorbed NOx when the oxygen in the exhaust gas decreases, is installed in the exhaust conduit; and

(2) to recover the NOx absorbent poisoned by sulfur oxide, the engine is controlled so that the exhaust gas becomes high in temperature in the presence of excess oxygen.

The object of Katoh is to prevent the NOx absorbent from being poisoned by sulfur oxide absorbed by the NOx absorbent (see column 6, line 31-35).

Since an object of the present invention is exhaust gas purification, the present invention is totally different from Katoh.

Regarding Leyer:

Leyer relates to a treatment of the exhaust gas of a gasoline engine and a diesel engine. These engines are controlled under such a condition that oxygen in the exhaust gas is excessive.

Used as a catalyst in Leyer is a platinum metal, a carrier having a large surface area, and in some cases, a base metal. The carrier having a large surface area is a carrier whose surface area is at least 150 m²/g even after the carrier is burned at 950°C for 7 hours.

Leyer does not disclose or suggest two types of exhaust gas disclosed in the claimed invention of the present application. Although the exhaust gas of the diesel engine corresponds to the exhaust gas containing excess oxygen disclosed in the claimed invention of the present application, Leyer does not disclose or suggest the exhaust gas containing less oxygen specified in the claimed invention of the present application.

Regarding the combination of Katoh and Leyer:

Neither Katoh nor Leyer describes a direct fuel-injection engine.

The direct fuel-injection is an engine in which gasoline is directly supplied into a cylinder, and is totally different from a

normal engine in which a mixture of gasoline and air mixed in advance is supplied into a cylinder.

Meanwhile, a diesel engine is an engine in which light oil is directly supplied into the cylinder, that is, a diesel engine adopts the same method of supplying fuel as the direct fuel injection engine. However, a gasoline engine uses gasoline (its boiling point is from room temperature to 200°C) as the fuel, and a diesel engine uses light oil (its boiling point is from 250°C to 350°C) as the fuel, so that these engines are totally different from each other.

Both technologies described in the above references do not assume the direct fuel-injection engine of the present invention at all.

Further, the above references and the present invention are totally different in that the gasoline engine of the above references use air (oxygen) which becomes carbon dioxide and water after the combustion of the gasoline whereas the claimed invention of the present application uses excess air.

For the reasons explained above, the exhaust gas purification process of the present invention would not have been reasonably expected based on the technologies of internal-combustion engines

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disclosed in the above references whose technical field is different from that of the present invention.

Removal of the 35 U.S.C. 103 rejection of the claims is believed to be in order and is respectfully requested.

The present paper is believed to place the application in condition for allowance. If, however, minor issues remain that can be resolved by means of a telephone interview, the Examiner is respectfully requested to contact the undersigned attorney at the telephone number indicated below.

In the event that this paper is not considered to be timely filed, applicants hereby petition for an appropriate extension of time. The fee for any such extension may be charged to our Deposit Account No. 111833.

In the event any additional fees are required, please also charge our Deposit Account No. 111833.

Respectfully submitted,
KUBOVCIK & KUBOVCIK



Ronald J. Kubovcik
Reg. No. 25,401

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Atty. Case No. HARA-072-046
The Farragut Building
Suite 710
900 17th Street, N.W.
Washington, D.C. 20006
Tel: (202) 887-9023
Fax: (202) 887-9093
RJK/jbf

Attachment: Excerpt from Taylor, K. "Automobile Catalytic Converters" in *Catalysis Science and Technology* (1984 ed.), vol. 5, pp. 122-123

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Chapter 2

Automobile Catalytic Converters

Kathleen C. Taylor

Physical Chemistry Department General Motors Research Laboratories
Warren, Michigan 48090, USA

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mean emission at 80,450 km to the least squares estimate of the mean emission at 6436 km is called the deterioration factor (df). [15]. The deterioration factors so established are then used to predict the 80,450 km emissions of data vehicles which have been driven for just 6436 km (4000 mi) by multiplying the 6436 km emissions by the deterioration factor. For a vehicle to be certified by the EPA, the extrapolated emission numbers cannot exceed the requirements shown in Table 1.

Emission control requirements have been established in the U.S. for medium and light-duty trucks (Table 2) and for heavy-duty vehicles. Requirements for trucks sold in California are stricter and have different vehicle weight classifications.

Table 2. Light/Medium Duty Truck Regulatory Emission Control Requirements*

| | 1981-1983 | 1984 |
|-----------------|-----------|------|
| HC | 1.7 | 0.8 |
| CO | 18 | 10 |
| NO _x | 2.3 | 2.3 |

* Units are g mi⁻¹. Federal definition of light duty trucks is ≤ 8500 gross vehicle weight.

The combined effect of new stricter emission control requirements for 1981, changes in the certification regulations over the years, different regulations for vehicles granted waivers, and changes in vehicles in order to simultaneously improve fuel economy and exhaust emissions is the use of many different catalysts by automobile manufacturers on 1981 and 1982 model year vehicles. For example, the total amount of noble metal and the Pt/Pd/Rh ratios differ among catalysts. Some vehicles have single three-way catalytic converters while others have dual-bed catalytic converters for which the first bed operates as a three-way converter, and air is added before the second bed which contains an oxidation catalyst. Catalyst supports are both alumina coated ceramic monoliths and alumina pellets.

3. Exhaust Emission Characteristics

The engine-out exhaust emissions of CO, HC, and NO_x vary as a function of air-fuel ratio as well as several other parameters such as ignition timing and EGR. Here we shall consider only the relationship to air-to-fuel ratio (A/F). A general relationship between engine out CO, HC, and NO_x emissions and A/F is shown in Figure 1. Engine operation at lean A/F (net oxidizing condition) results in lower HC and CO emissions and more O₂. These conditions favor subsequent catalytic oxidation reactions. At lean A/F the exhaust contains insufficient reducing agents to react with all the O₂ and all the NO. By operating closer to the stoichiometric A/F more NO

can react but the volume of CO which must be oxidized increases. The stoichiometric A/F occurs at about 14.6. Here, the concentrations of oxidizing gases and reducing gases are matched, and equilibration of the exhaust mixture would yield only CO_2 , H_2O , and N_2 . The application of three-way catalytic converters has this objective. Three-way catalysts operate in a narrow A/F band between 14 and 15.

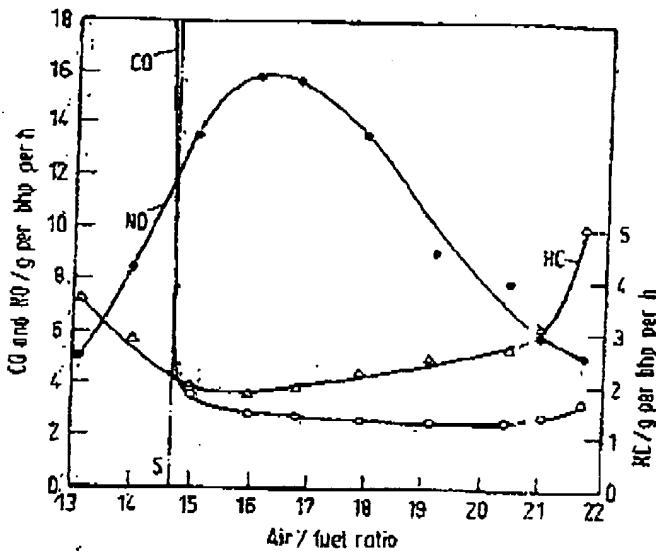


Figure 1. The effects of air-fuel ratio on -hydrocarbon, -carbon monoxide, and nitric oxide exhaust emissions. (Reproduced with permission from ref. [13].)

The exhaust hydrocarbons are a mixture of olefins, paraffins, and aromatics ranging from C₁ to C₈. Table 3 lists the important exhaust hydrocarbons [16]. The total and relative concentrations will vary depending upon the A/F and spark timing [16]. Other exhaust constituents include hydrogen which is present at a concentration of about 1/3 that of CO. Water vapor and carbon dioxide concentrations are each about 10% by volume. Sulfur dioxide emissions are 20 ppm for a corresponding sulfur level in the fuel of 0.03 wt %. The use of alternative fuels such as ethanol and methanol leads to an increase in the fraction of exhaust hydrocarbons emitted as aldehydes.

Other exhaust constituents which are significant because they can lead to deterioration of catalyst performance are phosphorus and lead. Phosphorus is present in the fuel (typically $0.02\text{--}0.1 \text{ mg P l}^{-1}$) but can also be derived from oil consumption. Motor oil typically contains 1.2 g P l^{-1} . Lead (as tetraethyl lead) is present at low levels (1 mg Pb l^{-1}) in unleaded fuel.

Engine-out emissions of HC, CO, and NO_x measured during FTP tests have been observed to fall within the following ranges: 1.3 to 2.5 g mi^{-1} HC, 10 to 17 g mi^{-1} CO, and 0.8 to 2.0 g mi^{-1} NO_x [17]. In order for these engine-out emissions to fall below the 1981 Federal emission control requirements (0.41 HC, 3.4 CO; 1.0 NO_x), percentage conversions of 70 to 90 percent for HC, 66 to 80 percent for CO, and 0 to 50 percent for NO_x are required.